Europäisches Patentamt
European Patent Office
Office européen des brevets

Publication number: 0 367 520 A2

EUROPEAN PATENT APPLICATION

Application number: 89311148.4

Int. Cl.5 D21F 1/44

Date of filing: 27.10.89

Priority: 03.11.88 GB 8825791

Date of publication of application: 09.05.90 Bulletin 90/19

Designated Contracting States: BE DE ES FR GB IT

Applicant: The Wiggins Teape Group Limited
P.O. Box 88 Gateway House Basing View
Basingstoke Hampshire RG21 2EE(GB)

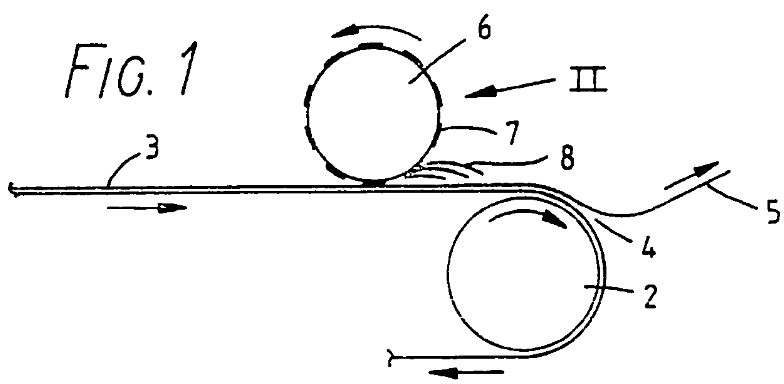
Inventor: Radvan, Bronislaw
24 The Meadows
Flackwell Heath Buckinghamshire,HP10 9LX(GB)
Inventor: Allen, David Robert
28, Brookside Road
Preston - Lancashire(GB)

Representative: Bridge-Butler, Alan James et al
G.F. REDFERN & CO. High Holborn House
52/54 High Holborn
London WC1V 6RL(GB)

Improvements in apparatus for forming watermarks in paper.

A paper machine having an endless foraminous element for engagement with a fibrous web during formation of the web into paper, said element having bonded thereto with flexible bonds, spaced flexible components each representing a surface configuration adapted to generate a watermark in said paper as a result of the engagement of said foraminous element with said web.

FIG. 1



IMPROVEMENTS IN APPARATUS FOR FORMING WATERMARKS IN PAPER

This invention relates to an improved apparatus for forming watermarks in paper.

A paper web is commonly manufactured by metering a dispersion of papermaking fibres onto a moving endless foraminous support, such as the "wire" at the wet end of a Fourdrinier paper machine through which drainage is effected. A roll, known as a "dandy" roll, having its cylindrical surface formed from a finely woven open metal mesh, may be located towards the end of the Fourdrinier wire so as to rotate lightly in contact with the web newly formed on the wire. This improves the compaction of the upper surface of the web.

In those cases where it is designed to form a watermark, designs conforming to the watermark image required are secured to the mesh surface of the dandy roll so as to stand proud thereof. The web on the Fourdrinier wire is subjected to greater compaction by the watermark designs during rotation of the dandy roll, and as a result, redistribution of the fibres occurs, resulting in local variations in the grammage of the sheet. Consequent variations in the concentration of fibres gives rise to variations in the light transmission in the dried paper, resulting in a visible watermark effect.

The watermark designs are formed on the dandy roll by soldering or brazing metal wire to the mesh surface of the roll in the configuration of the desired watermark image. Such designs, which are commonly known as "electrotype" designs have a uniform height above the supporting mesh. Because of this and the manner in which they are formed, they produce linear watermarks having a uniform visual contrast with the remainder of the paper. This technique is also commonly used for the formation of straight line "laid" patterns which simulate those to be found in hand made paper.

The use of a dandy roll imposes speed limitations on a Fourdrinier paper machine. First, the quality of the watermark formed deteriorates as the speed increases because of the reduced period during which the watermark designs are in contact with the web. Secondly, water inevitably picked up by the interstices of the metal mesh forming the surface of the dandy roll is thrown off as spray by centrifugal action as the rotational speed of the roll increases in dependence upon the speed of the Fourdinier wire. This problem can be overcome to some degree by increasing the diameter of the dandy roll, but this substantially increases its cost, and there are in any event practical limitations on the size of dandy roll which can be accommodated. As a result, conventional watermarking technology has imposed a ceiling on the speeds at which watermarked papers can be produced.

As a replacement for a dandy roll to carry watermark designs, United Kingdom Patent Specification No. 1447933 proposes the use of a flexible foraminous belt formed from a finely woven bronze wire mesh, typically of the kind commonly used as covers for dandy rolls. The belt has solid metal watermark designs fitted thereto by conventional techniques, for example soldering, brazing or welding and is mounted and tensioned around guide rolls for movement along a non-circular path bringing it into surface contact with the paper web to which watermarks are to be applied.

It has been found that during the movement of such a belt along its non-circular path, repetitive stresses are set up at the welded or brazed joints as the watermark designs pass around the guide rolls. Eventually the stresses cause fatigue fractures in the joints so that the designs detach partially or wholly from the belt. Even if maximum size limitations are imposed on the watermark designs or minimum diametric size limitations on the guide rolls, the joint fatigue problem persists, even though in a less acute form.

United Kingdom Specification No. 1447933 also addresses the problem posed by the fragility of the fine woven metal mesh. Attention is drawn to the need to avoid overstressing the belt by running it over rolls which are too small. Furthermore, in order to prevent damage or distortion arising from the tensile forces which must necesarily be applied, reinforcing meshes of metallic or plastics material are provided to support the fine metallic mesh. In general it is also well recognized that, apart from their high cost, fine metal meshes are susceptible to damage and are also difficult and costly to repair when damaged.

The invention therefore provides a papermachine having an endless flexible foraminous element for engagement with a fibrous web during the formation of the web into paper, said element having bonded thereto with flexible bonds, spaced flexible components each representing a surface configuration adapted to generate a watermark in said paper as a result of the engagement of said foraminous element with said web.

The foraminous element is preferably a woven mesh and may be of a metal such as phosphor bronze, but is preferably of a plastics material such as a polyester.

The flexible foraminous element may be the Fourdrinier wire of a paper machine, in which case the mark formed will be of a quality approaching that of a mould mark, or may in some cases be better in view of the long period during which the

web will drain in contact with the wire. The provision of watermark forming components on the Fourdrinier wire is however only practicable when long and repeated production runs of a particular watermarked paper are required. The high cost of producing a Fourdrinier wire carrying such components, together with the paper machine downtime involved in changing wires makes the use of such wires uneconomic for low volume short production runs.

Alternatively, the endless flexible foraminous element may be provided in the form of a woven mesh belt, located above the Fourdrinier wire, in substitution for a dandy roll. The belt extends around a driving roll and one or more idler and tensioning rolls and is arranged to have a portion of the belt running in parallel with the Fourdrinier wire for engagement with a fibrous web supported by the wire. A suction box may be located above this portion of the belt so as to effect upwards drainage and produce an effect somewhat similar to that produced by a vacuum cylinder mould machine. By having a long portion of the belt in contact with the web, as compared with the substantially tangential contact which occurs with a dandy roll, the time of contact is extended so that the pattern derived from the surface configuration of the flexible components carrying the watermark image is impressed more firmly.

Furthermore, by providing a second suction box above the belt at a position immediately after the belt has separated from the web, superfluous water picked up by the belt can be removed before the belt passes around a roll and the throw off of spray prevented.

The invention will now be further described with reference to the accompanying drawings in which:-

Figure 1 is a semi-diagrammatic sectional side elevation of the downstream end of the wet end of a Fourdrinier paper machine,

Figure 2 is a view on the arrow II of Figure 1;

Figure 3 is a sectional elevation on the line III-III of Figure 2,

Figure 4 is a semi-diagrammatic sectional side elevation of the downstream end of a Fourdrinier paper machine incorporating one embodiment of the invention and,

Figure 5 is a semi-diagrammatic sectional side elevation of the downstream end of the wet end of the Fourdrinier paper machine incorporating a second embodiment of the invention.

Referring first to Figure 1, this shows a Fourdrinier wire 1 extending around a couch roll 2 and supporting a fibrous web 3 which is lifted from the wire at 4 and passed to the conventional press and dryer sections of the paper machine in the usual manner at 5. A dandy roll 6 carrying electrotype watermark designs 7 as hereinbefore described is mounted above the Fourdrinier wire 1 for rotation cooperatively therewith. During rotation of the dandy roll 6 the watermark designs are brought into contact with the web 3 on the wire so as to apply differential compaction to the fibrous structure of the web in dependence upon the configuration of the design. This results in redistribution of the fibres and local variations in the grammage which are discernible by transmitted light as a watermark after the web 3 has been pressed and dried to form paper.

The speed of the machine shown in Figure 1 is limited by the speed at which the dandy roll 6 can be rotated without unacceptable deterioration in the quality of the watermark produced or the production of excessive throw off spray 8 which damages the paper surface.

Referring now to Figures 2 and 3, these show the way in which an "electrotype" watermark design is applied to the cylindrical mesh surface of the dandy roll. From Figure 2, it will be seen that the design 10 is formed from a wirelike element which is soldered to the cylindrical mesh surface 11 of the dandy roll and presents a minimal obstruction to the passage of water through the mesh. As best seen in Figure 3, the watermark design 10 stands proud of the mesh 11 so that the web 3 is subjected to greater compaction in the area of contact by the design than by the rest of the dandy roll.

Figure 4 shows part of Fourdrinier paper machine similar to that of Figure 1 and the same reference numerals are used for corresponding elements. In this case however the Fourdrinier wire 1 has bonded thereto flexible watermark designs 12 on which the web 3 is laid down and drained in part by a suction box 13. The nature of the flexible watermark designs 12 and the means of bonding then to the wire is described in greater detail below.

Because the web 3 is laid down as a dispersion on the components 12, drainage of the web takes place through the components. In addition, the components remain in contact with the web for the full length of the wet end of the paper machine. As a result, highly defined watermarks are produced which are comparable, for example, with the mould marks produced by a vacuum cylinder mould paper machine.

Turning now to Figure 5, this shows a Fourdrinier paper machine similar to that of Figure 1 and the same reference numerals are used for corresponding elements. In this case however an endless finely woven polyester mesh belt 20 is located above the Fourdrinier wire 1 in substitution for the dandy roll 6. The belt 20 extends around a drive roll 21, idler rolls 22, a tensioning roll 23 and under

a vacuum box 24 and a hold down roll 25. The vacuum box 24 is provided with a rounded corner 24a of nylon, high density polyethylene or a similar material constituting a low friction guide for the belt 20. Between the vacuum box 24 and the hold down roll 25, the belt 20 extends in parallel to the Fourdrinier wire 1 so that flexible watermark designs 26 bonded to the belt 20 are maintained in contact with the web 3. The nature of the watermark designs 26 and the means of bonding them to the wire is described in greater detail below.

The drive roll 21 is located such that the belt 20 separates from the web immediately after passing the hold down roll 25, but at a relatively low angle of, say 10 to 15° so as to minimise the film split effect at the point of separation. A vacuum box 27 is located above the belt 20 between the hold down roll 25 and the drive roll 21 so as to remove residual water held in the interstices of the mesh forming the polyester belt and thus preclude the generation of throw off spray as the belt passes around the drive roll 21. A suction box 28 is also provided beneath the Fourdrinier wire 1 at the point where the belt 20 separates from the web so as to ensure that the web 3 is held down on the Fourdrinier wire at this point.

The flexible components for generating the watermark may be bonded to the Fourdrinier wire or woven mesh belt by a variety of techniques of which examples are given below.

Example 1

Direct Casting of Polyurethane Watermark Designs

A photographic film positive and a mould of the required watermark design was first produced. This mould was in the form of an engraved brass plate. The mould was coated with release agent (Frekote 44 supplied by Dexter Corporation), and liquid polyurethane injected into the mould (Adiprene L-100, a suitable low temperature cure polyurethane marketed by Uniroyal). The mould was then placed in an oven for one hour at 90 degrees Celsius to effect a partial cure of the polyurethane.

A finely woven polyester mesh belt was prepared by coating with a photoresist emulsion (Dirasol 25 supplied by Sericol), and dried in a dark heated cupboard.

The photographic film positive was then positioned on the emulsion, taped in place and the mesh exposed to an Ultra Violet light source. The emulsion covered by the film positive remained uncured and water soluble. The film positive was then positioned on the reverse side of the mesh (using registration marks) and the reverse side then exposed to Ultra Violet light.

With the emulsion thus "developed", the mesh was immersed in a water bath and both sides sprayed with low pressure water jets to remove the uncured soluble emulsion. When the image of the watermark design was clear, the mesh was removed from the water bath and left to dry.

The mould containing partially cured polyurethane was next removed from the oven and the mesh laid over the mould, taking care to align the image in the photoresist with the polyurethane in the mould. The mesh was pressed firmly down onto the surface of the mould by the application of a uniformly distributed weight. The polyurethane, still being liquid, flowed into the interstices of the mesh before setting. The mould and mesh were then placed in the oven at 90 degrees Celsius to complete the cure of the polyurethane.

After 24 hours in the oven the polyurethane was found to be fully cured. The weight was removed, the mesh peeled off the mould carrying with it the polyurethane watermark designs.

The mesh was then immersed in a photoresist emulsion solvent (Seristrip supplied by Sericol) and the photoresist washed out leaving the mesh belt with sharply defined flexible polyurethane marks.

Example 2

Adhesion of Polyurethane Watermark Designs Using Polyurethane

The mesh belt was prepared as in Example 1 for the direct cast polyurethane method, that is the mesh was coated with a photoresist and the areas in which watermark designs were required washed out after curing.

Using the engraved brass plate moulds of Example 1, the watermark designs were cast from polyurethane and fully cured. The marks were then trimmed, and those containing voids or other irregularities rejected. Liquid polyurethane was then prepared and applied to the reverse of the watermark designs which were then placed in position on the mesh and pressure applied by means of a weight. The mesh and watermark design assembly was then put in the oven at 90 degrees Celsius for 24 hours to cure the polyurethane. On removal from the oven, excess polyurethane was trimmed off, the wire immersed in photoresist solvent and washed, to leave sharply defined polyurethane watermark designs firmly and flexibly adhered to the mesh belt.

Example 3

Flexible Thermoplastic Elastomer Marks Attached By Adhesive

The adhesive used was Tyrite 7617, a single-pack, moisture-cure Urethane adhesive marketed by Lord Industrial Adhesives. The thermoplastic elastomer was Hytrel 5556-P, a polyester marketed by DuPont. Watermarks designs were cut from a sheet of the elastomer and also precast therefrom. The mesh belt was prepared in Example 1. The watermark designs and the mesh belt were wiped with solvent (Isopropanol), and then coated with the adhesive. 15 to 30 minutes at room temperature were allowed for the solvent to evaporate before placing the two adhesive surfaces together. They were then pressed firmly together and a heavy weight placed on the designs. Twelve hours at room temperature was required before handling strength developed. The adhesive developed a full strength cure in 5-10 days. After completion of the cure the photoresist was dissolved with a suitable solvent to leave sharply defined designs firmly and flexibly adhered to the mesh belt.

Example 4

Ultrasonic Welding of Watermark Designs

An Ultrasonic plastic welding apparatus supplied by Lucas Dawe Ltd. was used. This consists of five components, a generator, converter, booster, horn and actuator. The solid state generator converts the 50 Hz mains electric power into high frequency electrical energy at 20K Hz, which is supplied to the converter. This in turn converts the electrical energy into mechanical vibratory energy at the same frequency, and this is transmitted via the booster to the horn or work tool which is directly in contact with one of the two work pieces to be welded together. The vibratory energy produces localised frictional heating at the interface of the two parts and causes the thermoplastic to melt and flow throughout the joint area. On completion of the cycle the plastic solidifies on cooling and produces a high strength molecular bond.

Strips of Hytrel 5556-P thermoplastic elastomer were welded to a polyester mesh belt using this method. The Hytrel then required trimming after welding to leave a sharply defined low profile mark.

Example 5

Direct Casting Of Polyurethane Watermark Design Onto A Finely Woven Bronze Mesh Belt

The procedure of Example 1 was repeated with a bronze mesh belt and the watermark designs were found to have adhered satisfactorily.

Example 6

Ultrasonic Welding of Watermark Designs To A Bronze Mesh Belt

The procedure of Example 4 was repeated using a bronze mesh belt and the watermark designs were found to have adhered satisfactorily.

Example 7

Embroidered Watermark Designs

Watermark designs and chain lines (for laid paper) were applied to a finely woven polyester mesh belt by embroidery, using cotton. Satisfactory designs were produced.

Example 8

A metal mould conforming to the shape of a required watermark design was slightly overfilled (to allow for contraction) with polyester copolymer fibres supplied under the trade name GRILON K150 by EMS-GRILON of Domat/Ems, Switzerland.

The mould was then covered with a release coated steel plate and the covered mould subjected, in a temperature controlled press, to pressure of 500 Kilo Pascals for 5 minutes at 150°C.

After cooling, the cured copolymer was found to have taken the form of a solid but flexible watermark design which could be readily removed from the release coated steel plate.

The mould, containing the cured design, was then inverted onto a finely woven polyester mesh belt of the kind used in Example 1. The release coated steel plate was then juxtaposed so as to trap the belt between the mould and the plate, the resulting assembly then being subjected to a pressure of 500 Kilo Pascals for 2 minutes 45 seconds at 150°C.

On cooling, and after removal of the mould and steel plate, the flexible watermark design was found to have fused firmly to the mesh belt whilst remaining fully flexible.

Flexible belt provided with watermark designs as described with reference to Examples 1 to 8 were all found to produce good quality watermarks on a paper web and, despite substantial running

times in a non circular path under tension, no tendency for the designs to detach from the belts was noted.

Claims

1. A paper machine having an endless foraminous element for engagement with a fibrous web during formation of the web into paper, said element having bonded thereto with flexible bonds, spaced flexible components each representing a surface configuration adapted to generate a watermark in said paper as a result of the engagement of said foraminous element with said web.

2. A paper machine as claimed in claim 1 in which said foraminous element is a woven mesh of metal.

3. A paper machine as claimed in claim 1 in which the said metal is phosphor bronze.

4. A paper machine as claimed in claim 1 in which said foraminous element is a woven mesh of a synthetic plastics material.

5. A paper machine as claimed in claim 4 in which said material is a polyester.

6. A paper machine as claimed in any one of the preceding claims in which said flexible foraminous element is the Fourdrinier wire of the paper machine.

7. A paper machine as claimed in claims 1 - 5 in which endless foraminous element is in the form of a woven mesh belt located above the Fourdrinier wire of the machine.

8. A paper machine as claimed in claim 7 in which said belt extends around a driving roll and one or more idler and tensioning rolls and is arranged to have a portion thereof running in parallel with the Fourdrinier wire for engagement with a fibrous web supported by said wire.

9. A paper machine as claimed in claim 8 in which a suction box is located above the said portion of said belt to effect upwards drainage.

10. A paper machine as claimed in claim 9 including a second suction box above said belt located immediately after said belt has separated from the web.

11. A paper machine as claimed in claims 1 - 10 in which said flexible components are made from an elastomeric material.

12. A paper machine as claimed in claim 11 in which the elastomeric material is a thermoplastic elastomer.

13. A paper machine as claimed in claim 12 in which the thermoplastic elastomer is a styrene block copolymer, a polyolefin blend, a polyurethane or a copolyester.

14. A paper machine as claimed in claim 11 in which the elastomeric material is a liquid polyurethane elastomer.

15. A paper machine as claimed in any one of the preceding claims in which said flexible components are bonded to said foraminous element by moulding under heat and pressure by adhesive or welding.

16. A paper machine as claimed in claim 1 and in which the flexible components were made and attached to the foraminous element by the methods set forth in any one of Examples 1 to 8.